SOIL DRIFTING CONTROL

IN THE

PRAIRIE PROVINCES

By
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ACKNOWLEDGMENT

The authors wish to acknowledge the very helpful assistance, in the preparation of this bulletin, of the staffs of the various Dominion Experimental Farms in the Prairie Provinces.

This method of summer-fallowing should be discontinued. Large fields of summer-fallow, with the surface soil worked down to a fine condition, promote soil drifting. The field should be stripped in narrow bands of crop and summer-fallow and should be cultivated so as to leave stubble at the surface or a cloddy surface soil. In extreme cases the summer-fallow should be protected by a light cover crop seeded about August 1.

SOIL DRIFTING CONTROL IN THE PRAIRIE PROVINCES

In some of the earliest reports of the Dominion Experimental Farms reference is made to the occurrence of soil drifting. Even as early as 1887 severe drifting was experienced on the Experimental Farm at Indian Head and throughout that district. Soil drifting is not of recent origin, therefore, but appears to have developed soon after the prairie lands were broken and seeded to grain. About 1918 determined efforts to control drifting were commenced in the Monarch district in Southern Alberta. These efforts have met with such decided success that this district is now regarded as the most outstanding example in Canada of successful control even in an area where severe drifting is liable to occur almost every year. More recently, similar methods have been adopted in a few other districts, chiefly as a result of united action by groups of farmers. Over the greater part of the Prairie Provinces, however, the intermittent occurrence of drifting from year to year, and the more or less widely separated areas involved, have probably discouraged any extensive attack on the problem. During the years from 1931 to 1934, however, soil drifting assumed such serious and widespread proportions and caused such tremendous damage to farm property that more definite action towards effective and permanent control has become imperative. This bulletin presents detailed information outlining the most successful methods now known of controlling drifting.

AREA INVOLVED

Few areas on the prairie are entirely immune from soil drifting. Wherever there is bare soil and the necessary combination of predisposing causes exists, more or less serious drifting may be expected unless some control measure is adopted. In this regard the practice of summer-fallowing, essential over the greater part of the prairie for the conservation of moisture, provides large areas of bare land. Approximately 12,993,000 acres of land were summer-fallowed in 1932 in the three Prairie Provinces out of a total cultivated area of 55,714,059 acres. Grain crops comprise 39,317,100 acres and constitute the principal type of crop grown in the three Prairie Provinces as will be seen by reference to page 31 of this bulletin.

OCCURRENCE

Observations indicate that extremely light and extremely heavy soils, such as sands and clays, are more susceptible to drifting than the soils collectively known as loam. In wooded or park areas, with natural protection against wind movement, soil drifting is relatively infrequent but on occasions has been quite serious. On the other hand, the open plains, which permit the unhindered passage of wind from every direction, constitute the areas most frequently affected. Even here conditions vary from one locality to another. Generally speaking, Southern Alberta, Southern Saskatchewan and Southwestern Manitoba form the areas most susceptible to serious drifting. Elsewhere there may be periods of several years intervening between the occurrence of severe dust storms. Drifting usually occurs during the spring months of April and May and, on occasions, during June. It is not an infrequent occurrence in Southern Alberta, even during the winter months.

CAUSES

The fundamental causes of soil drifting have received very little scientific study and on this account the causative factors are largely a matter of speculation. The elementary cause is obviously the action of wind upon loose, dry soil unprotected by vegetation. Soil drifting is thus more severe during seasons of drought or severe insect infestation when vegetation has beend destroyed and the soil has been left bare. It has occurred, also, on some soils where the surface, even after recent rains, has dried out rapidly. Observations have shown, however, that the mere action of high winds upon dry bare soil is not necessarily the prelude to serious drifting. The fact that the finer particles of drifted soil are lifted high into the air indicates a turbulence present in the wind. Temperature, too, appears to have a decided influence. A change in the direction of the wind, with no appreciable slackening in velocity, but accompanied by a decided drop in temperature, has been observed to result in a marked decrease in the severity of soil drifting.

Most observers are agreed that nwly-broken virgin soil seldom drifts. As long as the fibrous material of the original vegetation is present this acts as a binder to the soil particles. In the course of time, however, this fibrous material decomposes, the soil loses its soddy condition, and drifting develops as soon as the required conditions arise.

Cultivation of the soil expedites the destruction of the sod in newly broken land and thereby contributes materially in promoting a soil condition susceptible to drifting. This is true, also, of summer-fallow land. The primary purpose of such land is the storage of moisture, in the accomplishment of which the soil must be cultivated at intervals to eradicate weeds. Thus, while cultivation is essential for weed control, it may promote drifting if not properly done. The subject of weed eradication in relation to soil drifting is described on page 22 of this bulletin.

Contrary to general opinion, humus in a soil appears to facilitate drifting. Humus consists of decomposed organic matter, chiefly the residues of former vegetation. It gives to surface soil its characteristic dark colour. It is to some extent indicative of soil fertility and in addition imparts to soil several desirable physcal properties. In so far as it affects soil drifting, however, observers have reported that some of the soil in the park belt of high humus content readily drift when the predisposing causes arise. The reason suggested for this is that humus tends to prevent the soil from forming into clods that are so effective in checking wind action.

The repeated action of frost must be regarded, also, as a predisposing cause of soil drifting. In countries with high rainfall it is necessary to plough the land in the autumn in order to utilize the action of frost in improving the otherwise poor tilth of the soil. Such action is actually a detriment on dry farming, or on semi-arid soils, which naturally assume a satisfactory tilth. Frost action is probably responsible for much serious soil drifting, especially in Southern Alberta. Here, periods of frost are frequently alternated by the so-called "chinooks," strong winds of relatively high temperature and of decidedly low relative humidity. These winds evaporate any moisture which may be present in the surface soil and, if proper precautions are not taken, soil drifting may result. While the land remains covered with snow there is, of course, no danger from drifting.

Careful observations have shown that soil drifting is usually not a spontaneous action over a wide area, but originates at certain focal points and spreads very rapidly. These focal points in a field are frequently the tops of knolls or ridges or places where the soil is lighter, and more easily eroded by wind than the surrounding soil. Many of the suggested control measures are based upon the observation and in principle aim to check soil drifting in its incipient stage.

Access to this farm by vehicle traffic has been completely cut off and its abandonment forced by surrounding drifts of soil three to four feet deep.

DAMAGE CAUSED BY SOIL DRIFTING

Over extensive areas throughout the Prairie Provinces, very severe financial loss has been caused by soil drifting. In many instances farmers have lost their entire crop and have had the fertility of their land enormously reduced, certainly for many years and possibly permanently.

There is no method of accurately measuring the exact damage caused by soil drifting. One inch of surface soil blown from a single section of land means the movement of approximately 100,000 tons of soil. As several million acres are subject to drifting the aggregate movement of soil may be very great. This drifted soil is not actually lost, but is deposited in coulees, ditches and fences where its potential productiveness cannot be utilized. The value of this drifted soil can be compared on the basis of its chemical constituents, with equivalent amounts of the same elements contained in a wheat plant which secures these elements from the soil during its growth. Soil drifted from one acre, to a depth of one inch, is equivalent to the removal of approximately 694 pounds of nitrogen, 155 pounds of phosphorus and 5,380 pounds of potash. The above amount of phosphorus alone is approximately equal to that removed from the soil in the production of 485 bushels of wheat.

However, it is not merely the nitrogen, phosphorus and potash which are lost. The surface soil contains humus and living organisms which profoundly effect soil productivity. Experience has shown that the yields of crops on fields that have lost the top soil are often much lower than those secured on adjacent fields which have not drifted. It may take many years for such fields to approach their original productiveness if indeed they are ever completely restored.

The influence of drifting on soil productivity, as reflected in the yields of subsequent crops, varies greatly with different soil and subsoils. There are a few localities with deep soils that have had five or six inches of soil blown off and still produce good crops. In the majority of cases, however, where two to four inches of top soil have been lost, crop yields have been much lower for many years afterwards. In some cases the injury appears to be almost permanent.

Observations were made in 1934 by officials of the Dominion Experimental Sub-station at Regina to determine the amount of soil which might be moved by winds during a single season. Soil from a quarter section of summer-fallow land drifted over and was deposited more or less uniformly over an area of stubble land. Careful measurements showed that the material removed from this summer-fallow was equivalent to a loss of almost 1·25 inches of top soil from the whole quarter section or approximately 195 tons per acre.

The damage to growing crops by drifting soil is always very evident. Sometimes the germinating seed may be blown away with the soil and the same thing may happen to the growing crop before the plants are large enough to furnish the necessary protection against drifting. Plants that are large enough to protect the soil upon which they are growing may be injured and sometimes completely destroyed by soil, drifting from adjoining unprotected land. In such cases the moving particles of soil cause physical injury to the young plants which are dessicated by the dry winds, or the plants may be buried or smothered by a deep layer of drifted soil.

Drifting soils are also the cause of many other serious problems. The cost of maintaining railway right of ways is greatly increased. Highways are often drifted over and even made entirely impassable. Drifts collected along adjoining roadsides and fence lines furnish an excellent place for weeds to grow and produce seed. Fences that have become clogged with weeds form a check to the winds and may become completely covered with drifted soil. The same condition is experienced with shelter belts and field windbreaks which are often seriously damaged.

An extremely severe case of drifting in light soil. Surface and subsurface soils have been eroded to a depth of one to two feet. Checking further erosion and the reclamation of such soils present very difficult problems.

One of the most serious aspects of soil drifting is the drifting of soil around and into farm homes. The photographs on pages 25, 27, 31, show extreme cases, but by no means the only ones where drifted soil has covered fences and encroached on windbreaks and farmsteads. Living conditions under such circumstances are extremely disagreeable and often become almost unbearable.

If drifting did not cause any damage whatever to fields or crops and the only injury was to farm homes and their surroundings, its influence on the morale of the rural population, especially the housewives, makes this problem of tremendous importance. It is impossible to keep the dirt out of the home during dust storms. Grit and grime must be endured in food, in beds, in furniture and on the floors until the wind subsides and then it is necessary to clean thick layers of loose soil from everything, only to have the experience repeated with the next wind storm.

The farmstead is not the only home inconvenienced by drifting soils, although the actual injury there has been the most serious. Villages, towns, and even cities have found the dust blowing from adjacent farms a serious nuisance and localities far to the east have reported dust from the prairies settling out of the air. This has been so bad in some prairie towns that traffic on the streets has had to be abandoned during a wind storm. Driving under such conditions has caused accidents on town and country roads. Even in cities it has been necessary to use lights during the day, as is sometimes required in a dense fog.

CONTROL MEASURES

Cover Crops

Much of the soil drifting that occurs on the prairie is on summer-fallowed land. On this account most of the control measures have been developed for the protection of summer-fallow land.

A very effective method of controlling soil drifting, which is used on summer-fallows in some localities where a fair rainfall is received, is to protect the field with a cover crop. This consists of a late summer seeding of spring grain. If the crop makes a satisfactory growth the soil is effectively protected. Where the fall growth is very heavy, some excellent fall pasture is also secured. The cover crop, however, should not be pastured to the extent of destroying its protective value. In and near the foothills of Alberta, where moisture is fairly abundant, the use of cover crops is quite general and farmers maintain that the actual reduction in yields of subsequent grain crops, as a result of using cover crops is very small. During the dry years of 1932 to 1934 inclusive, on the heavy clay soils around Regina, where soil drifting was at times quite severe, the grain seeded on land previously in cover crops has actually yielded higher than on land on which there had been no cover crop and which had remained bare during the summer-fallow period. The lower yields of grain from the unprotected land appeared to have been partly the result of crop injury by drifting soil and partly the loss in productiveness through the removal of surface soil.

The chief objection to the use of cover crops is the loss of soil moisture by transpiration. While no specific studies have been made to determine the amount of water actually used by cover crops, experiments with cereals seeded in the spring indicate that the use of soil moisture increases very rapidly with crop growth. Another disadvantage may be encountered where the cover crop is subject to drought or grasshopper attack resulting in the loss of the cover crop and leaving the soil susceptible to drifting. There may be also a difficulty in controlling certain weeds where cover crops are grown. Where these difficulties have been experienced some farmers have adopted strip farming and are maintaining trash cover in addition to the cover crop.

Rates of Seeding.—The rate of seeding cover crops has been one-half of a bushel of spring wheat per acre or three-quarters of a bushel of oats or barley. These rates have produced very effective cover crops, which have prevented the drifting of summer-fallow land even under severe conditions.

Methods of Seeding.—A common method of seeding is that generally used in the seeding of ordinary grain crops except that the rate is considerably reduced. Another method is to seed with every other drill run closed. This latter method may be used to some extent where drifting is not very severe, but a general objection to it is that with a small amount of growth of the cover crop the more susceptible lands, such as sands and clays, tend to drift to some extent between the rows of grain. If for any special reason this method of seeding is necessary it should be done somewhat earlier in the season and at right angles to the prevailing winds, in order to secure greater protection.

A cover crop consisting of spring grain seeded around August 1, at the rate of about ½ bushel per acre is very effective in controlling soil drifting. After being killed by frost the cover crop is still very effective in checking drifting during the succeeding winter and spring months.

This photograph shows strip farming in the Monarch district in Southern Alberta where this method of controlling soil drifting has been extensively adopted. The farmers in this district not only practice strip farming but follow the best cultural practices to prevent drifting, including ploughless cultivation to maintain stubble and trash on the surface.

Dates of Seeding.—The optimum date of seeding cover crops cannot be set definitely for such a large area as the prairie where considerable variations in soil and moisture conditions occur. Variable conditions from year to year also influence the time at which it is best to seed a cover crop. Under most conditions the cover crop should be seeded about August 1. In the park areas where moisture conditions are favourable and fall pasture is desired cover crops could be seeded somewhat earlier. When grasshoppers are prevalent it is often advisable to delay seeding until later in the season when the majority have ceased feeding. On the other hand, where cutworms are present it is not advisable to seed later than August 1, since later cultural operations tend to favour cutworm activity. The principle involved in selecting the date of seeding of a cover crop is to seed early enough to ensure sufficient growth to protect the soil but not to seed so early that more growth is secured than is needed, and so avoid unnecessary depletion of soil moisture.

Choice of Cover Crops.—Information at present available does not indicate any appreciable difference in the protection afforded by spring cereals used as cover crops. It is preferable, however, to use the same kind and variety of grain for cover crop planting as will be seeded on the land in the following spring. This precaution will avoid contamination by volunteer plants from seed which did not germinate in the previous fall. Oats as a cover crop may be objectionable if the seed is not entirely free of wild oats.

Strip Farming

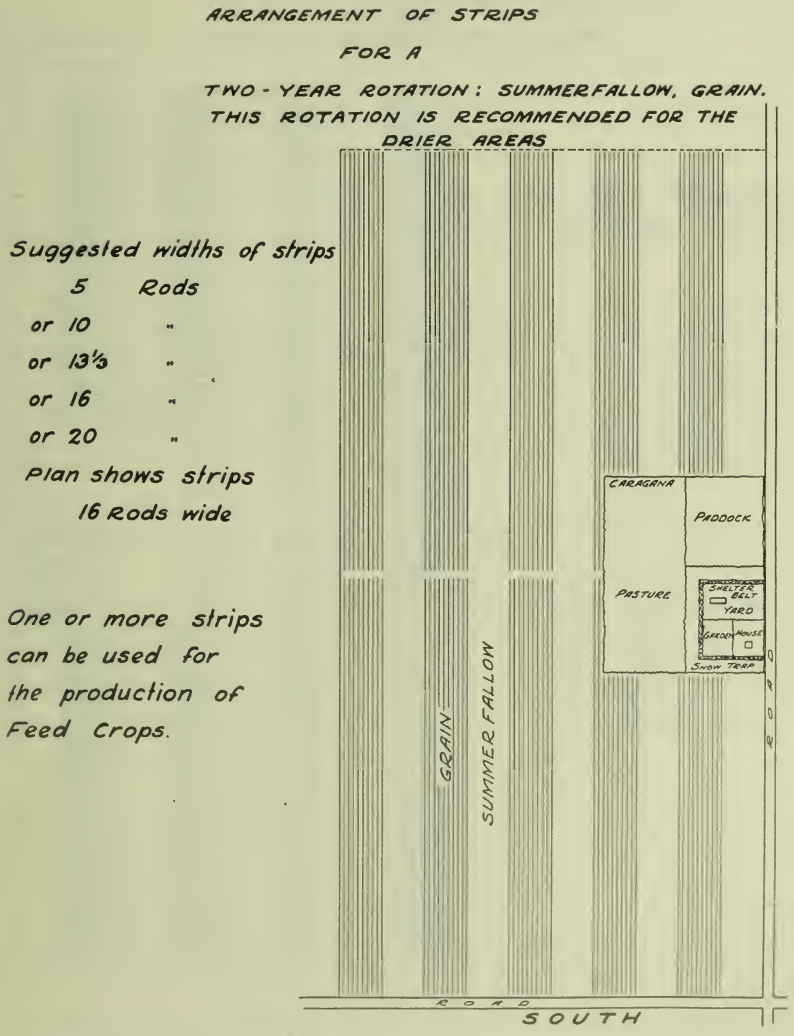
Origin of Strip Farming.—Strip farming is a method of soil drifting control which does not appreciably alter cropping practices. When the sod was first worked out of the soil and fallows began to drift many people advocated the abandonment of the summer-fallowing practice. Most farmers and investigators realized, however, the necessity of summer-fallowing, but many farmers became so discouraged in trying to keep the soil on their fallows that they either sold their farms or abandoned their land. Some who remained noticed that the last place to drift was on the west part of their fields and that the prevailing winds were generally from a westerly direction. They noticed also that frequently the west ten or twenty rods of the field did not drift at all if drifting conditions were not too severe. These observations soon led to a division of the fields into alternate strips of fallow and grain, a practice which has been so helpful that it has now been widely adopted, especially near Monarch in Southern Alberta where its value was first recognized.

Farmers in this region have been strip farming for over fifteen years. They have been able by this means, along with proper cultural practices, to practically prevent drifting on their farms, although unstripped fields in the same vicinity have drifted nearly every year. Some precautions are necessary, however, in using this method.

Precautions Necessary.—Notwithstanding the demonstrated benefits of strip farming numerous farmers have stripped their fields and yet soil from the summer-fallow has been blown over into adjoining stubble to form a series of ridges and depressions. This experience has undoubtedly arisen from a mistaken idea that stripping alone would prevent summer-fallow from drifting regardless of the condition of the soil. It is important, however, to ensure that the best cultural methods be adopted for summer-fallow strips, in order to secure as much trash cover as possible, and to maintain the soil in a lumpy condition, as outlined under "Ploughless Summer-fallow" on Page 14. Farmers who have had long experience with strip farming have learned, however, that stripping is only an aid, although a very useful aid, in holding their soil. One farmer expressed the situation very well in this way: "By carefully cultivating my summer-fallow strips I have had no drifting for eight years, but if my summer-fallow were in a large block I know of no way that I could conduct an effective fallow and keep my soil."

Arrangement of Strips.—Stripping is usually started on a field in the year when it is to be fallowed by dividing it into strips of the desired width, seeding alternate strips to spring grain and leaving the other strips to be fallowed. This arrangement of the strips is followed where the practice is to summer-fallow every other year. If the land is to be fallowed only once in three years two strips should be seeded to spring grain and the third one fallowed. Suggested arrangements in diagrammatic form are shown on pages 11 and 12.

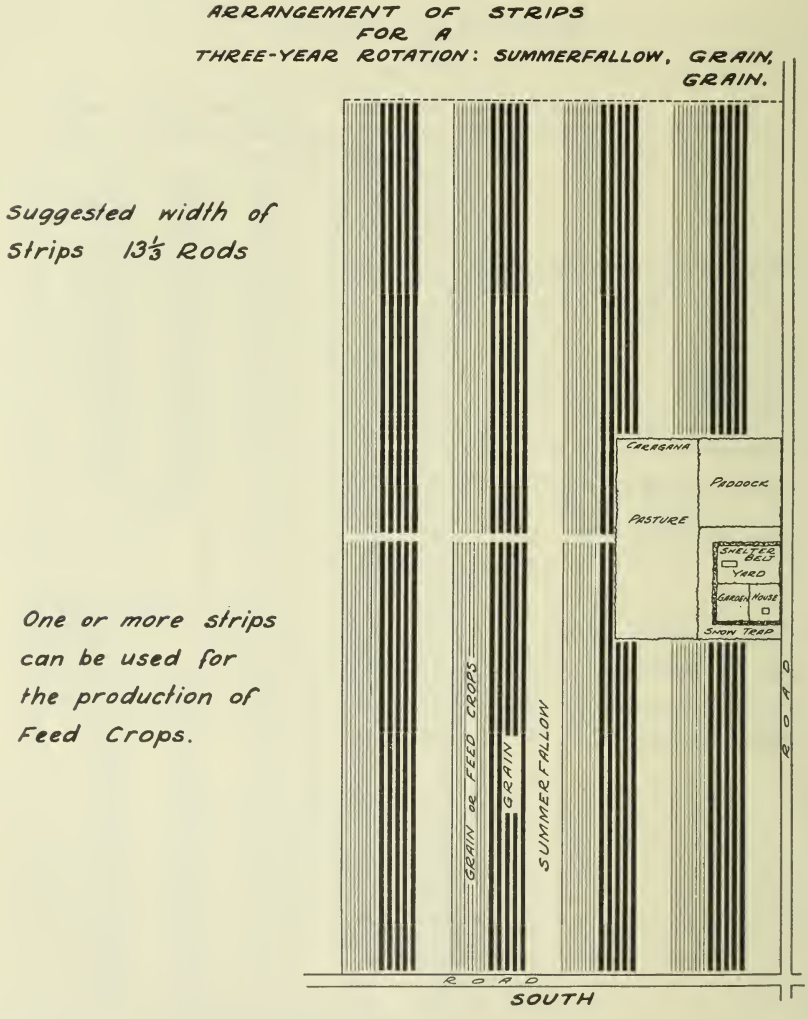
STRIP FARMING PLAN
FOR A
HALF SECTION FARM



Another method of starting strip farming is to seed the stubble land in strips in the fall to fall rye. The following year the fall rye may be cut for grain or hay while the intervening strips are summer-fallowed. If it is not desired to seed wheat on all the summer-fallow, strips of fall rye might be seeded

in the fall of the year the land is fallowed, the crop being cut for grain or hay, or strips might be seeded in the spring to green feed, intervening strips being seeded to wheat. In both cases the strips in fall rye or green feed should be ploughed immediately after the crop is removed so as to provide a partial summer-fallow. These latter methods of commencing strip farming are not considered as generally satisfactory as the method first outlined, but are suggested as alternatives in order to meet various local conditions.

STRIP FARMING PLAN
FOR A
HALF SECTION FARM



Direction of Strips.—Strips are usually laid down in a north and south direction, which is approximately at right angles to the most frequent winds. Some have thought that strips are of value only where drifting winds come from one direction, that is at right angles to the strips, but this is not substantiated by experience, as they have been found to furnish some protection from winds

striking them at almost any angle. North-south strips, for example, protect the soil from winds coming from any direction except due north or due south. It has been observed also that strips of stubble protect the soil from winds coming at an angle to the extent that they help to keep the soil from being broken down into a drifting condition. When a wind comes that is parallel to the strips the soil is usually not in a condition, therefore, to drift very readily.

Width of Strips.—The most satisfactory width of strip varies with the seriousness of drifting conditions, but is usually from 10 to 20 rods. On some light soils strips as narrow as 5 rods are used. Convenient widths of strips for a quarter-section of land would be 10 strips of 16 rods each, 16 strips of 10 rods each or 12 strips of 13⅓ rods.

Inconveniences.—Strip farming has some inconveniences, but surveys made by the Dominion Experimental Station at Lethbridge, Alberta, have shown that the cost of operation is not much greater on stripped than on unstripped farms. In fact farmers who are strip farming say that they have not found as many inconveniences as they expected and are usually enthusiastic over this method. One difficulty frequently encountered is the growth of weeds, particularly Russian thistle, around the edges of the strips of grain. This difficulty has been overcome by seeding, in addition to the summer-fallowed strips, about two or three feet of the directly adjoining stubble land. When the latter is cultivated during the subsequent summer-fallow period, the cultivator is allowed to extend about one foot into the grain and eventually the strips of seeded stubble are included in the cultivated area.

Under extreme conditions it has been suggested that a few feet off the outer edges of each strip of grain might be cut just prior to harvest when the crop was in the early dough stage for fodder purposes. While this practice is not necessary and is not followed in strip farming districts, it might have the advantage of providing firmer footing for heavy harvesting machinery, especially on loose ploughed summer-fallows, and it would remove any large weeds along the edges of the strips.

Occasionally there has been some sifting of soil from the fallowed strips into the stubble, resulting in a ridge of drifted soil being formed along the west edge of each stubble strip. Where farmers think there is danger of this they have adopted the practice of breaking down the stubble to a distance of one or two rods with a disk in the fall on the west side of each stubble strip. This permits any drifting soil from the summer-fallow strip to distribute itself quite evenly over the disked portion of the stubble strip and so no ridge is formed.

Under extreme conditions the above method may necessitate gradually moving the strips of summer-fallow and crop eastward across a field. This is accomplished by seeding the area of disked stubble on the west side of the strip in addition to the land previously summer-fallowed. The seeded strips are thus increased in width by one or two rods and those to be summer-fallowed are decreased by this amount. In the following fall the procedure of disking a strip of stubble on the west edge of each stubble strip is repeated. Next spring, the process of seeding the summer-fallow and strips of disked stubble is repeated with the result that the seeded strips and those to be summer-fallowed are once more of equal width, but in two seasons all strips have been moved eastward a distance of one to two rods. This practice creates an inconvenience at the east and west sides of the field but by adjusting the width of the strips at both these sides, this difficulty may be overcome. It is only on very rare occasions that it would be necessary to follow this practice.

TREATMENT OF THE SUMMER-FALLOW TO CONTROL DRIFTING

Two important methods of summer-fallowing land have developed on the prairie, one in which the land is ploughed and one in which the land is not ploughed, but is tilled with surface tillage implements only. These methods are usually called ploughed summer-fallows and ploughless summer-fallows.

Ploughless Summer-Fallow

The basic principle of the ploughless fallow is to keep down weed growth without burying the stubble or other trash in order to leave this material on the surface to form what has been termed a "trash cover" as a protection for the soil against wind erosion. It has been found that this trash cover should be anchored in the soil sufficiently, however, to prevent the trash from blowing away. Ploughless fallows with a trash cover have drifted less than any type of fallow and many farmers have had little or no drifting for a number of years with this type of summer-fallow on strips 20 rods wide or less. When used in conjunction with strip farming ploughless summer-fallow is an effective method of soil drifting control, in addition to retaining the full benefit of the summer-fallow in controlling weeds and conserving soil moisture. On the other hand, large blocks of summer-fallow , however, have drifted to some extent even when provided with a fair trash cover.

The surface soil has been completely blown away from this area. No vegetation has appeared on this wind swept spot from 1931 to 1934. The productivity of the land undoubtedly has been very seriously impaired.

Farmers who have a heavy combine stubble are able to use the one-way disk for the first and sometimes the second cultivation in conducting ploughless fallows. Usually, however, they use the one-way disk for the first cultivation and then the rod weeder continuing, if necessary, with the duck foot cultivator for subsequent cultivations. Where a fairly short, clean binder stubble is present the duck foot cultivator usually is used for the first cultivation and the rod weeder for later cultivations, if the land is loose enough for the rod weeder to operate. Quite frequently, however, it is necessary to use the duck foot cultivator ahead of the rod weeder to loosen up the soil. Narrow points are often used on the cultivator for this purpose. Farmers not in possession of a one-way disk are advised to use the ordinary disk harrow on long stubble.

As a rule cultivating rather than rod weeding should be the last cultural operation in the fallow season. The rod weeder leaves the surface level and the trash loose on top of the soil which may drift in the winter or early in the spring.

It is impossible, of course, to give definitely the dates or frequency of cultivation of a ploughless summer-fallow. The first might be given when the weeds have made good germination, possibly around the first of June. A second might follow by about the middle of July. A third cultivation may be required later, but it may be advisable to complete this work by August 1 if cutworms are feared. There is no object in cultivating late in the fall where only annual weeds are present as these will be killed by frost. It should be remembered that it is highly desirable to avoid too frequent cultivations, especially during seasons of low rainfall in order to minimize the possibility of drifting. Even in seasons of ample rainfall, when weed growth is profuse, four or five cultivations should be sufficient to control annual weeds.

Careful inquiry has shown that much of the drifting experienced in various parts of the prairies has been on ploughless fallows where the stubble and weed growth has been burned, or for some other reason no trash has been left as a cover to protect the soil. Ploughless summer-fallow should not be practised on fields unprotected either by stubble or weed covering unless a cover crop is seeded in the late summer. The presence of certain perennial weeds may prevent the use of a ploughless summer-fallow. Where farmers have been able to practice strip farming in conjunction with the ploughless fallow they have been successful in holding their soil. The ploughless fallow has also proved to very materially aid in reducing the amount of drifting in areas where strip farming is not practised, although the amount of drifting depends to a large extent upon the thickness of the stubble covering and the type of tillage implements used.

Ploughed Summer-Fallow

Ploughed fallows have been found to drift less readily than unprotected ploughless fallows, but they are by no means immune to soil drifting. With a good trash cover, however, the ploughless fallow is less disposed to drifting than a bare, ploughed fallow.

Many farmers who are practising strip farming on loam soils are conducting ploughed fallows quite safely by using methods which involve very little cultivation after ploughing. The usual practice is to cultivate at least once in May or early June before ploughing and in recent years a number of farmers have been cultivating twice before ploughing. This keeps down early weed growth, thus conserving soil moisture so that ploughing may be delayed until the latter part of July, when subsequent cultivation may be unnecessary. Where summer-fallows are cultivated before ploughing most farmers find it necessary to plough deeply so that two or three inches of the firm soil underneath the loose top soil will be turned up to the surface to form a cloddy cover.

Where a black fallow has been conducted for the control of Canada thistle or other similar perennial weeds, fall ploughing often gives the necessary winter protection. Deep ploughing is especially important on such fallows to maintain a cloddy condition, although where drifting is of no consideration ploughing to a depth of more than four or five inches has not been beneficial from the standpoint of crop yields.

A few farmers on the heavy clay lands near Regina have practised an unusual means of controlling soil drifting. This consists of floating the surface soil to a perfectly smooth condition. It is believed that lumps of soil, inequalities in the surface, or projections of any kind, tend to create eddy currents in the wind. These eddy currents, it is believed, are the primary cause of drifting. The success of this method depends upon the care and thoroughness with which the surface soil is smoothed and also the correctness of the assumption that

wind turbulence arises from the movement of wind across a roughened soil surface. Such a method could not be applied to soils other than the clay typical of the Regina plains. In fact with most soils a cloddy surface is highly desirable in the control of drifting. Until further evidence is available on the effectiveness of this method, other methods of control such as have been outlined in this bulletin are recommended.

Spring Treatment of Summer-Fallow

The summer-fallow should be watched during the winter months, if the land is bare of snow, and also in the early spring. If signs of soil drifting are observed preventive measures should be employed immediately. These are described in detail under the heading of "Emergency measures." A fairly deep cultivation is often required in the early spring to prevent ploughed summer-fallows from drifting.

When provided with ridging shovels placed 3 to 4 feet apart, the cultivator is useful for emergency soil drifting control measures. The surface of a field can be quickly transformed into a series of ridges and hollows with this implement.

It is almost invariably a good practice to cultivate the soil immediately before seeding to destroy weeds. If after this treatment there is danger of soil drifting it may be advisable to use the duck foot cultivator, set deeply enough to bring up lumpy soil to the surface. Where the surface soil is dry and loose it may be necessary to use the cultivator provided with narrow teeth or the spring-tooth harrow in order to penetrate to moist soil and to bring up clods to the surface. As with summer-fallowing it is a good practice to use as little tillage as possible by which weeds will be destroyed and a lumpy condition of the soil created.

From the Dominion Experimental Farm at Brandon, Manitoba, comes a recommendation to cultivate the summer-fallow in the early spring, using a cultivator provided with narrow points, and not to exceed a depth of two or three inches. This cultivation is done while the land is still moist from the melted snow. Seeding is done immediately in order to utilize the soil moisture in promoting a more rapid germination, thereby hastening the maturity of the crop and reducing the liability of crop injury from rust.

EMERGENCY MEASURES

Although the use of some permanent means to control soil drifting is highly desirable, emergency measures may be employed where systematic precautions have not been observed. Emergency measures can be used to advantage where soil drifting is of relatively infrequent occurrence and has not reached serious proportions. In some cases these measures must be applied while soil drifting threatens, or is actually in progress. On these occasions prompt and energetic action is also essential. It may be necessary sometimes to supplement a permanent control practice with emergency measures. In principle these emergency measures closely resemble the permanent practices in that they aim to place obstructions in the path of moving soil in order to check drifting before it can assume appreciable proportions.

Land worked with a cultivator provided with ridging shovels offers a very effective barrier to the movement of soil. This land must be levelled, of course, before seeding.

Under certain conditions soil drifting may occur during the winter months. In such cases the disk is operated over the partially frozen ground to roughen the surface soil

The following emergency measures have been found very effective:—

1. Listing summer-fallow fields in the fall.
2. Ploughing furrows one rod apart through the field.
3. Ridging by means of the duck foot cultivator.
4. Application of straw.
5. Disking during winter months.

Summer-fallowed fields on which it is feared that soil drifting may take place during the fall or winter may be ridged or listed in the fall. This form of ridging may be done by equipping every third or fourth shank of the duck foot cultivator with a ridging shovel as shown in the photograph of this arrangement on page 16. Equipped in this manner the cultivator is used in the fall to make furrows three to four feet apart across the field at right angles to prevailing winds. To be effective the furrows should be deep enough to throw up two or three inches of new soil to form a lumpy protection at the top of the furrows. The placing of shovels on every fourth shank appears more desirable than to have them closer as a flat ridge is left between the furrows. This ridge resists wind action for a longer period than a narrow V-shaped ridge.

An objection raised to listing is that when the field is levelled in the spring, which is usually done by cultivating with a duck foot, the furrows are filled with dry soil and if the spring is dry uneven germination may result. Farmers who have listed their fields in this way for several years, however, have had little difficulty with faulty germination.

Ploughing furrows one rod apart through the field has furnished some protection. This has been done most frequently when drifting threatened on seeded fields. Harrowing has kept some seeded fields from drifting where a surface crust had been formed that the harrow could break up into lumps. As an extreme emergency in seeded fields the duck foot cultivator may be used on focal points such as knolls or ridges while drifting is in progress.

The duck foot cultivator is employed quite extensively for ridging summer-fallow and ploughed stubble land. Some people on light soils condemn the use of this implement for ridging. There is little question that if this implement is used at all for ridging the shovels must go deeply enough into the soil to bring up lumps from below and to permit the loose top soil to sift down. A narrow toothed cultivator is sometimes more useful for this purpose when the top two or three inches of soil is dry and loose. Deep cultivation of this nature in the fall, winter, or spring has undoubtedly saved many fields.

Covering drifting fields with straw is being practised more extensively than many realize; in fact, in a few localities this practice is quite common. One farmer who spread straw over about seventy-five acres reported that it required three days to do this work with three men and two teams. This method is especially desirable when drifting starts on seeded fields. If the straw is spread on spots as they first start to drift it is often unnecessary to cover the entire field. Straw covering is also one of the effective means of checking winter drifting when the soil is frozen and the lister or cultivator cannot be used.

In the "chinook" area a single disking may be quite effective on thawing soil as the disks will run on top of the frost and will puddle the wet top soil that is thrown up by the revolving disk. The disks running on the frozen subsurface soil vibrate sufficiently to shake off the mud in most soils. The photograph on page 17 is an illustration of the use of a disk under these conditions. Double disking has not been found as effective as single disking as the second disking tends to pulverize the lumps made by the first operation. Puddling with a harrow has also been of advantage in some cases.

TREATMENT OF STUBBLE LAND TO CONTROL DRIFTING

Soil drifting is not often experienced on stubble land that is being prepared for spring grain unless the stubble is burned off and a high wind comes up before the field is cultivated after burning. There have been a number of occasions, however, when burned-over fields have drifted out to the bottom of the plough furrow in a few days where they have been left without cultivation.

Loam soils that have had the stubble burned off are not likely to drift for some time after they have been cultivated but sandy or flaky clay soils that are so treated may drift badly before the crop makes sufficient growth to furnish the necessary protection. Stubble should not be burned, therefore, on soils that drift readily, but the seed-bed should be prepared by cultivating so as to leave stubble on the surface as a protection.

Shallow spring ploughing has been satisfactory for medium soils and good results have been secured by cultivating and seeding stubble land in one operation with a one way disk equipped with a seeder attachment.

Fall ploughing of stubble is not recommended when the soil is dry, in fact, ploughing under these conditions is not good practice at any time as soil ploughed when dry has a tendency to break down to dust quite readily by the action of the weather. Numerous experiments have also shown that smaller yields may be expected on stubble land ploughed in the fall when dry than on spring ploughing. As a result of very marked reductions in the yields, even on spring ploughed stubble, ploughing has been completely abandoned on some heavy clay soils, the land being surface worked.

Where the soil is moist, fall ploughing is usually satisfactory for loam soils but dangerous for sand and some clay soils. Where the surface soil is extremely dry and loose, and yet not drifting, it may be inadvisable to disturb such land unless absolutely necessary for weed control.

MACHINERY FOR SOIL DRIFTING CONTROL

The aim in selecting farm machinery is essentially to secure equipment that will do the desired work in the most efficient manner. Tillage implements are primarily designed for the efficient control of weeds. However, where soil drifting may occur great care should be exercised in the use of these implements as too frequent or too thorough tillage promotes drifting.

Field Cultivator.—The field cultivator is probably the most serviceable of tillage implements for soil drifting control. Its chief merits are that it produces a minimum of soil pulverization and is fairly effective in the destruction of weeds. Equipped with duck feet, it may be used for the cultivation of ploughless fallows with a minimum destruction of trash covering. It may also be used on ploughed fallows, both before and after ploughing, and for the spring cultivation of summer-fallow land. Equipped with narrow points, the cultivator may be used to loosen the soil prior to rod weeding. The cultivator may be equipped, also, with ridging shovels as shown in the photograph on page 16, and be used for ridging as described under "Emergency Methods." Although adaptable to a wide range of conditions the field cultivator may become clogged in heavy stubble or land infested with Russian thistle. By removing the clogged material at intervals, however, satisfactory work may be done even under quite adverse conditions.

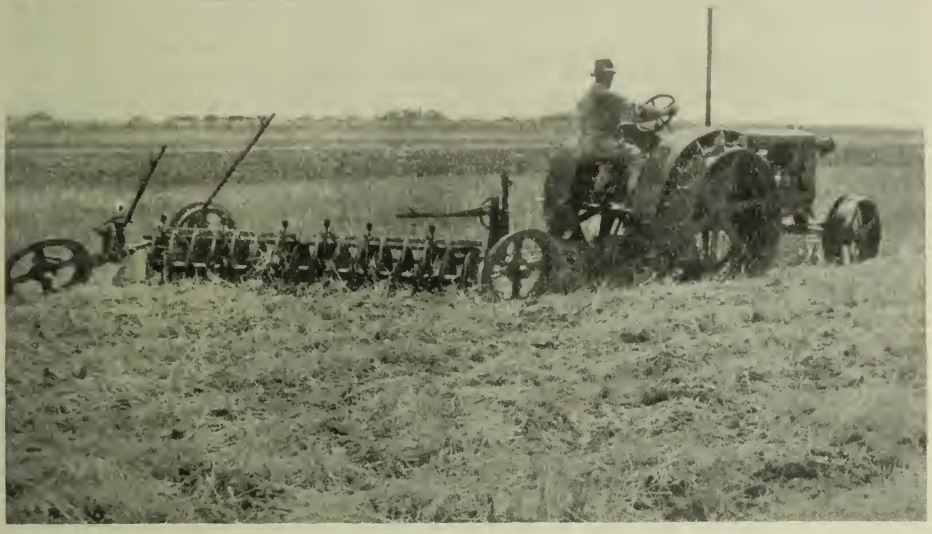
One-way Disk.—The one-way disk is of value for soil drifting control in that it mixes surface soil with any vegetative cover that may be present, is effective in destroying weeds, and leaves the soil in a somewhat roughened condition. This implement has been particularly useful for the first operation on heavy combine stubble, on a heavy growth of weeds or on a combination of both in the preparation of ploughless summer-fallow.

It is usually not advisable to use the one-way disk for the second operation on a ploughless fallow as there is danger that the trash may be covered too thoroughly, leaving insufficient protection. Similarly, it is very inadvisable to use the one-way disk in light, clean, binder stubble as preparation for ploughless fallow. The short stubble may be covered so completely as to afford no protection for the ploughless fallow.

Where soil drifting may occur, the duck foot cultivator performs several very useful functions. It may be used to prepare the soil instead of ploughing. It is very effective in destroying weeds. It does not unduly disturb the surface soil and it leaves stubble and trash at the surface as a protection against drifting.

Rod Weeder.—The rod weeder is one of the most satisfactory weeding implements where soil drifting is feared and where conditions are satisfactory for its operation such as level fields, friable soil and relative freedom from stones,

as it leaves the surface of the soil undisturbed. This implement is used chiefly on summer-fallow after the cultivator or one-way disk. The use of the cultivator and rod weeder forms a very satisfactory practice for destroying weeds and



The one-way disk can be used in many cases to displace the plough. It is useful in heavy stubble as much of the stubble is left partially buried at the surface where protection against soil drifting is provided. In short stubble the use of a duck foot cultivator is preferable as the one-way disk may bury the stubble completely. Unless very weedy, stubble should not be burned in districts where soil drifting may occur.

The rod weeder is a very useful implement for destroying weeds on summer-fallow land. The soil should first be loosened by the plough or cultivator the latter implement being used for the final operation for the season. The rod weeder cannot be used in very stony land.

maintaining a protective covering of trash on the surface of the soil. The rod weeder does not create a lumpy surface, it merely preserves an existing condition of the surface soil. The cultivator should be used as a final operation on the

fallow. The rod weeder is also used extensively to eradicate weeds on ploughed summer-fallows and in certain areas also for spring cultivation of summer-fallow prior to seeding.

Disk Harrow.—While an excellent implement for shallow cultivation and the preparation of newly broken land, the common disk harrow is not an effective implement for destroying well rooted weeds and probably pulverizes the surface of cultivated soil to a greater extent than other tillage implements if the soil is dry. Considerable judgment should be exercised in its use to minimize soil drifting. The disk harrow cannot be advocated for use on ploughless summer-fallows under most conditions. It may be used to advantage, however, for spring disking of summer-fallow land that is to be ploughed later, or to cut up a growth of Russian thistle to facilitate the use of the cultivator. This implement is useful for checking winter and early spring drifting, when only the top soil has thawed, and is also used extensively for spring disking of stubble land in preparation for seeding.

Spike Tooth Harrow.—Considerable care should be exercised in the use of this harrow, particularly on dry soil, to avoid creating a pulverized smooth surface. The harrow may be used, however, under certain conditions to puddle wet soil and to roughen it to form some protection against possible drifting. This operation may be performed in the winter or early spring while the snow is melting. This puddling process has saved many fields from drifting. Similarly, seeded fields that are wet or crusted may be protected temporarily by harrowing to form a cloddy condition either by breaking up the crust or by puddling the wet soil. On dry, friable soils it is not advisable to use the spike tooth harrow after the seed drill.

Seed Drills.—Although the standard types of seed drills were not designed specifically for use in the control of soil drifting, it is possible to adjust these implements to assist in this purpose. In cases where the soil is readily pulverized it is advisable to disconnect the covering chains when seeding with the disk seeder. Some farmers have reported satisfactory results from the use of a hoe drill. This implement performs the function of a cultivator as well as seed drill and leaves the soil slightly ridged. The pulverizing action of the hoes upon the surface soil is also much less than that of the disks.

SOIL DRIFTING AND WEED CONTROL

The summer-fallow, in addition to conserving soil moisture, provides an excellent opportunity for weed control. With the land free of crops it is possible to secure effective control of weeds by repeated cultivation. Unfortunately frequent cultivation of the soil increases the drifting hazard. On the other hand, weeds must be controlled if soil moisture is to be conserved. Obviously the soil requires careful treatment under these conditions if drifting is to be avoided, weeds controlled and moisture conserved.

The usual practice for the eradication of perennial weeds is to maintain a so-called black fallow. By means of repeated cultivations the shoots of such weeds as Canada thistle and perennial sow thistle, can be prevented from making their appearance and the root systems of these weeds are in time destroyed. It is essential that cultivation be done frequently and in a very thorough manner.

Where perennial weeds are present on heavy clay soils, and where drifting may occur as a result of frequent cultivation of the summer-fallow, it is advisable to introduce a partial summer-fallow. Land to be summer-fallowed by this method may be seeded to oats for green feed, an early maturing barley, or in the previous autumn to fall rye. These crops are harvested early and the land cultivated and kept black until fall according to the ploughless fallow method

outlined on page 14. This partial summer-fallow method is not very efficient in conserving soil moisture and would not be very applicable under dry conditions.

The control of annual weeds such as Russian thistle, mustards and wild oats, where the hazard of soil drifting exists, is not such a difficult matter as the control of perennial weeds. The ploughless fallow method is advisable, conducted with as few cultivators as possible.

It is sometimes advisable, where conditions favour quick germination to use a heavier rate of seeding grain so that it may compete effectively with the weeds. Competition of this nature has been secured in some areas where the growth of a grain crop has been stimulated with light applications of phosphate fertilizer. In any case, of course, the cultivator should precede the seed drill to destroy any weeds that have germinated.

If wild oats and stinkweed are very prevalent spring preparation of summer-fallowed land prior to seeding may be delayed for about two weeks, or until these weeds have germinated. Early seeding and a heavy rate of seeding are advisable, however, where the soil is infested with Russian thistle.

Surface cultivation in the preparation of summer-fallow land is more effective than ploughing in the eradication of annual weeds from the surface soil. This method has the advantage, mereover, of leaving the stubble on the surface so as to check soil drifting. A properly prepared surface-cultivated summer-fallow should leave the land fairly clean for the following crop. On very weedy land the two-year rotation of summer-fallow and wheat is quite effective in weed control. Where a three-year rotation is desired, thorough surface cultivation in preparation for a second crop of grain may promote a cleaner crop.

In regions where grasses and clovers can be grown successfully in crop rotations they are quite effective in controlling many weeds.

CROP ROTATION IN RELATION TO SOIL DRIFTING

Soil and climatic conditions over the three Prairie Provinces vary considerably and on this account some variation in farming practices is to be expected. Over the greater portion of these areas the production of grain forms the most important agricultural activity for the reason that these crops have returned the most profit. The reader is referred to the appendix for statistical information on agriculture in the three Prairies Provinces. The summer-fallow forms an important feature in the agricultural practices in these provinces, chiefly as a means of conserving moisture and combating weeds. The summer-fallow, with relatively large open areas of bare soil, presents an ideal setting for the development of soil drifting. It should be stripped or seeded to a cover crop and it should be cultivated in such a manner as to prevent drifting.

Where moisture conditions are favourable it is possible to modify the strictly grain rotations, used in the drier areas, and to introduce mixed farming rotations containing crops other than grain. Such rotations allow for a certain proportion of the land to be seeded each year to hay or pasture crops and in warmer and moister regions to corn or other summer-fallow substitutes. The growing of these crops divides the farm into smaller fields and assists in the solution of the soil drifting problem. Full advantage should be taken of these crops where they can be grown successfully.

Even in the so-called park areas soil drifting may occur although the most suitable rotations for such areas have been adopted. It is unwise, therefore, to leave large fallowed blocks of land unprotected.

For more detailed information regarding the choice of rotations suitable to the various conditions on the prairies the reader may consult Bulletin No. 98, New Series, of the Dominion Department of Agriculture, "Crop Rotations and Soil Management for the Prairie Provinces."

The following are examples of some typical mixed farming rotations suitable to different areas. A three-year rotation suitable for certain requirements in the park areas of the three Prairie Provinces is as follows:—

Three-year Rotation

1st year—Wheat.
2nd year—Wheat or coarse grain seeded to sweet clover.
3rd year—Sweet clover.

In this rotation coarse grains such as barley or oats cut early for green feed may be used for the control of weeds. Sweet clover is also helpful in weed control. If desirable, wheat may be partially replaced by corn or other fallow substitutes.

Another very useful rotation may include a fallow and a grass or legume hay for sod formation.

Four-year Rotation

1st year—Fallow or corn.
2nd year—Wheat, seeded down to sweet clover.
3rd year—Hay or pasture; plough in July.
4th year—Coarse grain.

Where it is desired to leave the hay or pasture crops for two years in succession, the following arrangement of a six-year rotation has been found very satisfactory.

Six-year Rotation

1st year—Fallow or corn.
2nd year—Wheat.
3rd year—Hay.
4th year—Hay or pasture or both.
5th year—Wheat.
6th year—Coarse grain.

In the above rotation the hay may consist of alfalfa, sweet clover, western rye grass or mixtures of these and other grasses. The coarse grain may be oats or barley.

In the drier regions of the prairie, which constitute a very large proportion of the territory, it is generally recognized that conditions are not favourable for forage crops and that summer-fallow to conserve moisture is a primary necessity. A common rotation in these areas is a three-year rotation of summer-fallow, grain crop, grain crop, but, where conditions are extremely dry, the two-year rotation of summer-fallow and grain is preferable.

On the sandy soils of the plains, which are found to be extremely susceptible to soil drifting, farmers have been forced to abandon the summer fallow and to adopt a continuous rotation of a grain crop consisting of wheat and fall rye seeded directly into the stubble. While this cropping practice is extremely undesirable from the standpoint of weed control and moisture conservation it appears to be the only alternative to the abandonment of such land. On light soils less susceptible to soil drifting the fallow is incorporated into a three-year rotation of summer-fallow, fall rye, wheat. Soil drifting on the summer-fallow is to some extent prevented by the rye in the fall of the year. Objections to this rotation are the relatively low value of the rye crop and the possible volunteering of the rye in the succeeding wheat crop. In addition it is difficult to establish a stand of all rye on summer-fallow due to winter-killing in some years in areas of insufficient snow cover. Wheat seeded continuously has sometimes been followed but the seeding is delayed until about June 1, to allow for spring tillage to destroy weed growth and permit quick germination following June rains.

Winter wheat is grown to some extent in Southern Alberta both on fallow and stubble following spring wheat. Where winter wheat is seeded on summer fallow the fall growth affords some protection against drifting, but as seeding must be delayed until the first of September, in order to avoid possible injury by root-rot, growth in the fall is usually not sufficient to insure protection against drifting especially on large unstripped fields. If a good fall growth is obtained it may furnish sufficient protection, however, for strips ten or twenty rods wide. Where winter wheat is seeded directly into the stubble of a preceding crop of wheat, soil drifting, of course, is completely prevented.

PROTECTION OF FARMSTEAD AGAINST DRIFTING SOIL

No discussion on the subject of soil drifting control would be complete without reference to protection of the farmstead and particularly the farm home. Many farmsteads are now provided with efficient shelter belts, but the problem of keeping dust out of the homes still awaits solution. Observations have shown that drifting soil is effectively checked in its movement across unbroken prairie land even though the vegetative cover is quite sparse. It is

Drifting soil and severe droughts have ruined many farmstead shelter belts. Proper precautions should be taken to protect shelter belts against drifting soil. This may be accomplished by means of trap hedges or rows of sunflowers on the windward side.

suggested, therefore, that wherever possible a strip of land, at least 20 rods wide, be seeded down as a permanent pasture on the windward side of the home. This pasture area should encircle the shelter belt, or at least extend along the sides exposed to the most frequent winds. A suggested arrangement will be found in the charts on pages 11 and 12. Such provision, of course would not entirely check the infiltration of dust into farm homes, but if coupled with carefully conducted control measures on the cultivated fields would aid materially in lessening the discouraging effect produced in farm homes by severe dust storms.

Further protection in addition to that provided by the farmstead shelter belt can be secured by planting caragana to form a hedge around the outer edges of the pasture area. Still further protection of course would be secured by the establishment of caragana hedges around the whole cultivated area. The possibilities in this scheme, however, have not been thoroughly explored. In areas where soil drifting is prevalent, hedges are difficult to establish. Russian thistle and other tumble weeds become caught in the hedges and result in the

collection of sufficient drifted soil to frequently smother the hedges. Such hedges, however, afford protection for the farmstead shelter belt against weeds and drifting soil. As caragana requires several years in which to develop, immediate protection may be provided by seeding several rows of sunflowers. The heads may be removed and the stalks left standing over winter. For informa-

An uncertain future lies before this splendid shelter belt. Drifts of soil three feet deep are lodged within its twelve-foot width.

tion regarding the establishment of hedges and shelter belts and supplies of necessary material, the reader is invited to communicate with the Dominion Experimental Farm, Forest Nursery Stations at Indian Head, Sask, and Sutherland, Sask.

COMMUNITY ACTION

While individual effort is usually very effective in controlling soil drifting and every farmer should adopt the best known control measures on his own farm, the most successful results will undoubtedly follow the adoption of community action. The importance of this community action will be readily understood from the fact that an area of unhindered, drifting soil usually expands very rapidly. Moving particles of soil are not always brought to rest by collision with stationary soil particles and in many cases the latter are caused to join in a general movement under the influence of high winds. The most carefully planned and executed control measures may be entirely ruined if the soil has to withstand the combined action of wind and drifting soil from adjoining unprotected areas. These facts show the necessity for community action if a maximum degree of success in the control of soil drifting is to be obtained. While the control of drifting on any farm is primarily the concern of the individual farmer, his success may be aided or hampered by the action of his immediate neighbours.

In order to prevent losses to neighbouring property by unprotected summerfallow, the Legislative Assembly of the province of Alberta passed an act in 1935 known as the "Control of Soil Drifting Act." This act places the responsibility on the owner of the land for damage done to adjacent property by soil drifting from his farm, unless he has used drift control measures as prescribed in the act. No claim for damages may be made by any person, however,

unless the claimant himself is complying with the act in regard to soil drifting control measures. The act comes into force on the 1st day of March, 1936. The following clauses indicate some of the measures which may be adopted to prevent damage to adjacent property and thereby avoid the penalties imposed by act:—

Clause 2.

"It shall be the duty of the occupier of land which is being summer-fallowed to till the same in such a manner as to prevent soil on any part of the summer-fallowed land from drifting so as to cause damage to adjacent land and property.

Drifting soil not only covers fences but in many cases very seriously interferes with highway traffic.

In many instances such as this, tumbling weeds have been caught in fences and drifting soil has accumulated to such an extent that both the weeds and fences have been entirely buried.

Clause 3.

"The occupier of any land which is being summer-fallowed shall be deemed to have discharged the duty imposed upon him by this act if each quarter-section upon which land is being summer-fallowed is cultivated according to any of the methods following, namely:—

"(*a*) By summer-fallowing and cropping the land in alternate strips not exceeding twenty rods in width approximately at right angles to the prevailing direction of wind liable to cause soil drifting or

"(*b*) By surrounding all summer-fallowed land with a strip of land of at least thirty rods in width cultivated in three strips paralleling the edge of the summer-fallow of which the inside and outside strips are each at least ten rods in width and are either under a grain corp or in stubble, and the remaining strip is summer-fallowed or

"(*c*) By surrounding all the summer-fallowed land with a strip of land of at least thirty rods in width paralleling the edge of the summer-fallow which is under a growing crop of grain or which is in stubble or

"(*d*) By seeding upon the land a covering crop of grain sown not later than the tenth day of August, using for that purpose not less than twenty pounds of seed per acre on all of the land which is under summer-fallow, or by seeding the land to fall wheat or fall rye on or before the first day of September; or

"(*e*) By maintaining a strip of natural or planted tree growth at least three rods in width within forty rods of and along the whole of each boundary of the property."

This Alberta act indicates the gravity of allowing unprotected summer-fallow to damage adjacent land and property. Where a farmer is located adjacent to land belonging to a neighbour who declines to adopt any measures to control drifting it would be necessary to attempt to protect his own land to the best of his ability. This may be done to some extent by seeding to green feed in June a strip of land about 20 rods wide adjacent to the neighbour's property.

The promotion of measures to control soil drifting might well be undertaken by community organizations in the Prairie Provinces. While the farmer and his family are the chief sufferers, the inhabitants of towns and cities are also unwilling victims during severe dust storms. Radical changes from present farming practices will not be required. Some changes, however, are absolutely imperative. It is probable that the most effective measures for controlling drifting will include a combination of several methods on individual farms and community action throughout entire districts.

APPENDIX

In view of the severe character and prolonged duration of the drought and soil drifting conditions which have prevailed in the three Prairie Provinces from 1931 to 1934, it has seemed advisable to present a series of tables showing the crop yields and precipitation records over a long period of years. With these data available, the reader may study for himself the variable character of the returns and, to some extent, estimate the possibilities of the various regions. Undoubtedly, the variable factors of precipitation, yield and price have combined to produce widely different revenues for the farmer, these fluctuations in revenue often extending throughout cycles of several years in succession.

The three Prairie Provinces of Manitoba, Saskatchewan and Alberta comprise the most important areas of field crops in Canada. In these provinces in 1934 there was a combined total of 38,701,720 acres under field crops, or 69 per cent of the entire area of field crops in Canada. When it is considered that approximately 8,457,000 acres of cropped land were affected by drought and soil drifting in these provinces in 1934 and that the yield of wheat in this area averaged less than 5 bushels per acre, the extent and severity of the drought and soil drifting will be realized.

Crop yields vary widely from year to year and even throughout periods of several successive years. The province of Saskatchewan has suffered the most severely of any of the provinces during the period from 1929 to 1934. For three years the provincial average yield of wheat was under 9·0 bushels per acre. Alberta experienced its lowest yield in 1918 with only 6·0 bushels per acre, while Manitoba had its smallest yield of 10·9 bushels per acre in the rust year of 1916.

These provincial average yields, however, do not reveal the severity of the recent drought and soil drifting which have occurred, as well as do the yields in certain crop districts where conditions have been most extreme. A study of the average yields in individual crop districts, therefore, will show which districts have been most effected and how small the returns have been in these areas. Even these yields are averages over a considerable area, indicating that many farmers in some districts have failed to harvest any crop whatever.

In crop district No. 3 in Saskatchewan, with an area of approximately three million acres seeded to wheat, the average yield for the six-year period from to 1929 to 1934 was only 5·4 bushels per acre with an average return value of only $2.98 per acre. For the four-year period from 1931 to 1934 the return was even less with a value of only $1.73 per acre. However, as will be seen by reference to the table entitled, "No. 3 Crop District, Saskatchewan," very much better yields and returns were secured during the period from 1922 to 1928. In 1928 the total value of the wheat crop was $66,166,100 in this crop district while in 1934 it was only $3,410,200. These figures indicate how severely the purchasing power of the farmer in this crop district has been reduced.

The amount of precipitation in the three Prairie Provinces decreases from Winnipeg, Manitoba, west as far as Medicine Hat, Alberta, beyond which there is a progressive increase as far as the foothills of the Rocky Mountains. At every point wide fluctuations have occurred from year to year. The degree of fluctuation appears to become wider as the total annual precipitation decreases. Thus, at Winnipeg in a period of 49 years, where the annual precipitation has averaged 19·92 inches, the fluctuation has varied from 13·76 inches to 27·19 inches, or as 1 to 1·97. At Medicine Hat, with an annual precipitation of 13·18 inches, the fluctuation has been from as low as 6·38 inches to as much as 25·28

inches, or as 1 to 3·96. At Qu'Appelle, Saskatchewan, an intermediate point, the corresponding relationship between the lowest and the highest annual precipitation has been as 1 is to 2·7.

Precipitation is frequently characterized by heavy showers of short duration when much of the rainfall may be lost by run-off. Many showers also are of such small proportions that the moisture they furnish is almost immediately lost by evaporation. Under average conditions moisture is the limiting factor in crop production over extensive areas, particularly on the open plains. When below average conditions prevail crop production is beset by many difficulties, of which drought and soil drifting are the most serious.

A study of the precipitation records presented in this bulletin will show the wide variations occurring from year to year and during cycles of several years in succession. Sometimes a single dry year is followed by a single wet year while at other times groups of wet and dry years succeed each other. A careful examination of these records, over periods of 50 years' duration, does not indicate any permanent change in the precipitation, either increase or decrease. Different localities have different amounts of precipitation as well as different intensities of evaporation but all localities have wide annual variations.

TOTAL ACREAGE AND VALUES OF FIELD CROPS BY PROVINCES

Table 1.—Total Acreages of Field Crops

Province	1915	1927	1932	1934
	acres	acres	acres	acres
Prince Edward Island	481,930	533,463	476,200	473,000
Nova Scotia	727,260	702,127	536,000	554,800
New Brunswick	893,800	889,277	907,500	906,300
Quebec	4,901,760	6,877,900	5,832,100	5,950,300
Ontario	9,391,500	10,305,045	9,224,300	8,999,900
Manitoba	4,843,816	5,968,983	5,866,800	6,000,900
Saskatchewan	13,036,596	19,527,971	22,333,900	19,771,820
Alberta	4,570,918	10,971,761	14,019,000	12,929,000
British Columbia	292,880	395,783	437,700	454,400
Total	* 39,140,460	56,172,310	59,633,500	56,040,420

Table 2.—Total Value of Field crops

Province	1915 Value	1927 Value	1932 Value	1934 Value
	$	$	$	$
Prince Edward Island	10,930,400	13,420,800	6,393,000	9,054,000
Nova Scotia	19,536,700	18,597,000	10,206,000	12,995,000
New Brunswick	20,092,600	18,413,500	12,629,000	14,961,000
Quebec	104,683,000	144,273,000	70,382,000	98,309,000
Ontario	207,043,500	255,900,000	113,904,000	143,734,000
Manitoba	92,318,800	82,280,000	28,981,000	50,233,000
Saskatchewan	265,605,700	348,005,000	80,046,900	94,440,600
Alberta	93,514,200	272,743,300	83,331,000	108,499,000
British Columbia	11,625,700	19,501,000	10,714,000	12,749,000
Total	825,370,600	1,173,133,600	416,586,900	544,974,600

(From Canada Year Book)

In 1934 in the three Prairie Provinces approximately 8,457,000 acres of cropped land were affected by drought and soil drifting. In this area wheat yields averaged less than 5 bushels per acre.

The enormous extent of the drought area can be appreciated from the fact that it exceeded the cropped acreage of several of the other provinces combined.

ACREAGES IN CROP, SUMMER-FALLOW, AND NEW BREAKING IN THE PRAIRIE PROVINCES AND CANADA, 1932

TABLE 3

Crop	Manitoba	Saskatchewan	Alberta	Three Prairie Provinces	Total six other provinces	All Canada
	acres	acres	acres	acres	acres	acres
Wheat	2,651,100	15,543,000	8,201,000	26,395,100	787,100	27,182,100
Oats	1,463,500	4,364,700	2,704,800	8,553,000	4,595,400	13,148,400
Barley	1,123,300	1,329,500	701,300	3,154,100	603,500	3,757,600
Rye	40,600	482,500	183,100	706,200	67,600	773,800
Flax	49,300	381,200	15,200	445,700	8,000	453,700
Mixed grain	17,000	20,800	25,300	63,100	1,120,900	1,184,000
Cereal hay	.....	.....	1,850,000	1,850,000	49,500	1,899,500
Hay	464,200	159,400	288,100	911,700	8,566,000	9,477,700
Other crops	58,930	58,100	52,729	169,759	1,586,941	1,756,700
New breaking	50,000	166,900	255,600	472,500	.....	472,500
Summer-fallow	1,732,000	7,257,200	4,003,800	12,993,000	*725,341	*13,718,341
Total acreage under cultivation	7,649,930	29,763,300	18,280,929	56,694,159	18,110,282	73,804,441

*Calculated from 1921 census.
Provincial figures from Provincial Reports, other figures from Canada Year Book.

In addition to the above acreages there were 7,601,592 acres of improved pasture in Canada in 1921 of which 790,045 acres were in the three Prairie Provinces. These acreages do not include range or unimproved pasture which amounted to 39,608,874 acres in all Canada of which 32,841,357 were in the three Prairie Provinces.

Surrounded by mounds of drifted soil and choked with sand it has been impossible to move this threshing equipment which has had to be abandoned.

ACREAGES, PRODUCTION AND VALUE OF THE WHEAT CROP IN CANADA

Table 4.—Acreages of Wheat

Year	Manitoba	Saskatchewan	Alberta	Total acreages	
				Prairie Provinces	All Canada
	acres	acres	acres	acres	acres
1910	2,760,371	4,228,222	879,301	7,867,894	8,865,000
1920	2,705,622	10,061,069	4,074,483	16,841,174	18,232,374
1928	2,660,125	13,790,854	6,707,526	23,158,505	24,119,140
1933	2,536,000	14,743,000	7,898,000	25,177,000	25,991,100
1934	2,533,000	13,262,000	7,501,000	23,296,000	23,986,300

Table 5.—Production of Wheat

Year	Manitoba	Saskatchewan	Alberta	Total production	
				Prairie Provinces	All Canada
	bush.	bush.	bush.	bush.	bush.
1910	34,125,949	66,978,996	9,060,210	110,165,155	132,048,782
1920	37,542,000	113,135,300	83,461,000	234,138,300	263,189,300
1928	52,383,000	303,399,000	155,662,000	511,444,000	533,571,100
1933	32,500,000	123,841,000	94,500,000	250,841,000	269,729,000
1934	37,100,000	114,200,000	112,500,000	263,800,000	275,252,000

Table 6.—Value of Wheat

Year	Manitoba	Saskatchewan	Alberta	Total Value	
				Prairie Provinces	All Canada
	$	$	$	$	$
1910	27,304,000	46,217,000	6,254,000	79,775,000	99,530,000
1920	68,769,000	175,360,000	126,861,000	370,990,000	427,357,300
1928	48,192,000	233,617,000	117,008,000	398,817,000	426,013,000
1933	15,600,000	55,728,000	38,745,000	110,073,000	122,864,000
1934	24,115,000	67,378,000	61,875,000	153,368,000	163,972,000

The largest total production of wheat in Canada was in 1928, with a yield of 533,571,100 bushels. This was almost double the production of 1933 or 1934. The wheat crop of 1927 had the greatest value amounting to $477,791,000.

WHEAT YIELDS IN THE PRAIRIE PROVINCES

TABLE 7.—YIELD PER ACRE

Year	Manitoba	Saskatchewan	Alberta
	bush.	bush.	bush.
1910	12·4	15·8	10·3
1911	22·6	20·7	22·3
1912	22·2	19·2	21·6
1913	19·0	21·2	22·7
1914	14·8	13·7	21·0
1915	24·8	25·1	31·1
1916	10·9	16·3	25·0
1917	16·7	14·2	18·2
1918	16·3	10·0	6·0
1919	14·2	8·5	8·0
1920	13·9	11·2	20·5
1921	11·1	13·7	10·3
1922	19·2	20·2	11·2
1923	12·3	21·3	28·0
1924	16·9	10·2	11·0
1925	17·8	18·5	18·0
1926	22·6	16·2	18·5
1927	14·0	19·5	27·4
1928	19·7	23·3	25·5
1929	13·7	10·7	12·0
1930	18·3	13·7	18·6
1931	11·1	8·9	17·7
1932	16·6	13·6	20·4
1933	12·8	8·4	12·0
1934*	14·6	8·6	15·0
Average 25 years	16·5	15·4	18·2

(From Canada Year Book).

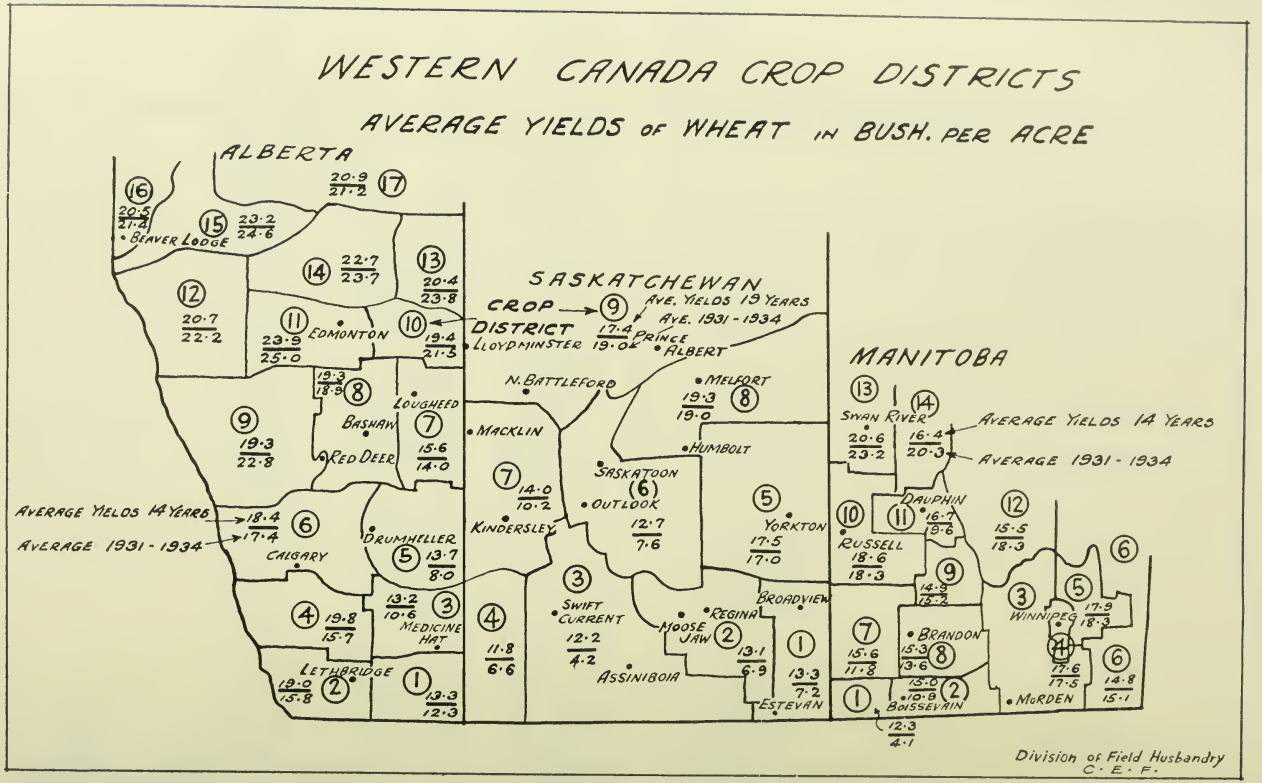
*Estimate January 24, 1935.

From 1929 to 1934 the province of Saskatchewan, as will be seen from the above figures, has been most seriously affected by drought and soil drifting. Alberta experienced its most severe drought in 1918 while Manitoba had its lowest yield in the rust year of 1916.

AVERAGE YIELDS OF WHEAT PER ACRE IN THE CHIEF WHEAT PRODUCING COUNTRIES

TABLE 8

—	Number of years' records	Average yield per acre
		bush.
Canada	20	16·0
Manitoba	25	16·5
Saskatchewan	25	15·4
Alberta	25	18·2
United States	20	14·4
Kansas	19	12·9
Nebraska	19	13·1
North Dakota	19	9·7
South Dakota	19	10·8
Minnesota	19	13·4
Montana	19	12·0
India	20	11·0
Russia	14	10·2
Argentina	20	11·1
Australia	20	11·3
Italy	20	17·6
France	20	20·5
England	18	31·0
Germany	18	29·4


WESTERN CANADA CROP DISTRICTS
AVERAGE YIELDS OF WHEAT IN BUSH. PER ACRE
ALBERTA
SASKATCHEWAN
MANITOBA
CROP DISTRICT
AVE. YIELDS 19 YEARS
AVE. 1931 - 1934
AVERAGE YIELDS 14 YEARS
AVERAGE 1931 - 1934
BEAVER LODGE
EDMONTON
RED DEER
BASHAW
LOUGHEED
CALGARY
DRUMHELLER
MEDICINE HAT
LETHBRIDGE
LLOYDMINSTER
PRINCE ALBERT
N. BATTLEFORD
MELFORT
MACKLIN
HUMBOLT
SASKATOON
OUTLOOK
KINDERSLEY
SWIFT CURRENT
MOOSE JAW
REGINA
BROADVIEW
ASSINIBOIA
ESTEVAN
YORKTON
SWAN RIVER
DAUPHIN
RUSSELL
BRANDON
BOISSEVAIN
MORDEN
WINNIPEG
Division of Field Husbandry
C. E. F.

WHEAT YIELDS IN MANITOBA BY CROP DISTRICTS

TABLE 9.—YIELD PER ACRE

Year	Crop Districts													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.
1921	5·7	9·3	11·9	16·9	16·7	9·4	10·9	10·8	12·7	15·6	12·6	11·2	20·3	11·0
1922	17·7	17·8	19·0	19·8	20·6	20·6	20·3	16·2	16·0	26·5	20·0	22·4	26·0	18·4
1923	9·8	9·6	9·6	12·9	12·8	11·7	13·5	9·5	10·3	16·7	11·9	12·4	17·9	13·6
1924	16·4	16·3	19·9	20·0	17·9	15·9	17·1	17·5	14·9	12·9	15·4	9·9	14·5	14·7
1925	18·5	18·7	18·3	17·8	18·9	13·7	17·1	19·6	15·0	18·3	12·9	14·3	20·0	14·6
1926	23·1	24·7	22·6	22·6	23·7	16·5	22·5	23·4	18·5	22·5	18·6	13·9	23·6	17·0
1927	16·7	15·6	10·7	10·8	11·0	11·0	16·5	11·1	10·8	18·5	11·5	11·4	14·0	10·6
1928	20·7	21·7	16·1	21·8	21·5	16·3	21·0	20·8	20·5	21·6	19·2	19·9	20·4	17·8
1929	13·2	12·1	14·4	16·5	15·5	14·3	14·1	12·5	12·4	15·2	14·2	14·2	20·2	13·4
1930	14·2	20·6	19·3	17·6	18·8	17·0	18·3	17·9	16·8	18·8	17·1	17·5	19·2	16·7
1931	1·7	6·5	13·6	15·7	18·3	14·9	7·5	9·9	11·5	14·6	19·2	15·9	22·0	22·2
1932	10·8	16·5	15·0	16·4	14·9	13·9	16·1	16·3	16·8	22·3	18·6	19·0	22·7	19·9
1933	3·5	11·8	13·9	14·5	14·8	14·2	12·2	13·2	14·7	18·7	19·6	15·4	24·4	22·0
1934	·6	9·0	19·7	23·3	25·3	17·4	11·3	14·9	18·0	17·7	21·0	19·1	23·7	17·3
Average 14 years	12·3	15·0	16·0	17·6	17·9	14·8	15·6	15·3	14·9	18·6	16·7	15·5	20·6	16·4

(From Manitoba Provincial Crop Reports)

In Crop District No. 1, the district most seriously affected by drought and soil drifting in Manitoba, the yield of wheat during the four years from 1931 to 1934, was only 4·1 bushels per acre. However, during the nine-year period from 1922 to 1930 the average yield was 16·7 bushels per acre or four times as much.

WHEAT YIELDS IN SASKATCHEWAN BY CROP DISTRICTS

TABLE 10.—BUSHELS PER ACRE

Year	Crop Districts								
	1	2	3	4	5	6	7	8	9
	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.
1916	8·2	11·7	14·3	18·1	15·4	15·7	18·0	16·9	17·5
1917	14·9	13·2	12·5	12·2	19·2	14·4	13·2	17·3	13·5
1918	10·3	12·1	8·1	4·7	16·0	11·8	5·2	21·3	6·8
1919	9·9	10·6	5·8	3·5	20·3	9·4	6·8	13·0	6·0
1920	9·3	10·2	11·0	9·9	15·0	8·5	13·8	15·6	17·3
1921	9·8	11·9	14·1	8·6	16·8	14·5	13·2	22·3	29·3
1922	23·2	23·2	24·2	18·7	21·2	16·0	12·2	24·2	16·0
1923	15·1	17·5	21·0	18·0	19·4	22·6	28·0	23·7	27·1
1924	14·8	12·8	13·9	6·8	10·1	6·3	5·6	8·9	9·1
1925	17·2	19·3	17·7	9·8	19·9	17·7	21·3	25·3	20·8
1926	24·0	21·9	16·5	8·8	19·6	12·9	12·5	18·7	16·3
1927	18·0	17·8	17·3	26·9	20·5	18·9	20·5	19·8	21·1
1928	20·2	21·8	25·8	27·1	21·9	22·3	24·0	20·9	20·5
1929	16·1	7·9	6·8	13·2	14·3	10·6	12·1	19·6	13·9
1930	13·9	11·7	8·4	13·7	16·0	10·9	19·9	24·1	29·3
1931	4·9	1·8	3·1	5·7	10·9	8·5	13·4	22·0	23·3
1932	11·9	11·0	8·3	15·7	17·2	11·6	16·9	22·0	20·7
1933	8·2	12·1	3·7	4·0	23·1	5·3	3·8	16·3	14·1
1934*	4·5	4·0	2·0	2·5	16·5	7·0	7·5	16·5	18·0
Average 19 years	13·4	13·3	12·3	12·0	17·5	12·9	14·1	19·4	17·5

*Estimated.
Sources—Provincial Reports 1928 and 1934.

Crop Districts Nos. 1, 2, 3, 4, 6 and 7 comprise the areas in Saskatchewan most seriously affected by drought and soil drifting. A comparison of the very small yields received during the years from 1929 to 1934 with the years immediately preceding shows how seriously these districts have suffered from drought and soil drifting.

No. 3 CROP DISTRICT SASKATCHEWAN

TABLE 11.—PRODUCTION AND VALUE OF WHEAT CROP

Year	Total acreage	Average yield per acre	Total production	Average price per bushel	Total value of wheat crop	Return value per acre
		bush.	bush.	$	$	$
1916	1,476,257	14·3	21,110,475	1·28	27,021,408	18·30
1917	1,450,532	12·5	18,261,330	1·95	35,609,594	24·37
1918	2,068,279	8·1	16,831,242	1·99	33,494,172	16·12
1919	2,486,197	5·8	14,436,506	2·32	33,492,694	13·46
1920	2,132,449	11·0	23,456,938	1·55	36,358,254	17·05
1921	3,193,377	14·1	45,023,480	·76	34,217,845	10·72
1922	2,940,050	24·2	71,296,000	·85	60,601,600	20·57
1923	3,198,400	21·0	67,181,163	·65	43,667,756	13·65
1924	3,249,155	13·9	45,219,000	1·21	54,714,990	16·82
1925	3,242,429	17·7	57,413,000	1·10	63,154,300	19·47
1926	3,029,043	16·5	49,859,000	1·08	53,847,720	17·82
1927	3,312,086	17·3	57,175,300	·97	55,460,000	16·78
1928	3,366,082	25·8	85,920,000	·77	66,166,100	19·87
1929	3,610,959	6·8	24,472,000	1·03	25,484,260	7·00
1930	3,572,400	8·4	30,009,000	·47	14,104,230	3·95
1931	3,667,900	3·1	11,336,000	·38	4,307,680	1·18
1932	3,725,100	8·3	30,986,000	·35	10,845,000	2·90
1933	3,551,800	3·7	13,204,000	·45	5,941,800	1·67
1934*	2,800,000	2·0	5,780,000	·59	3,410,200	1·18

* Estimated. (From Saskatchewan Provincial Crop Reports).

The average yield of wheat for the seven-year period, from 1922 to 1928, was 19·5 bushels per acre with an average return value of $17.85 per acre. In the succeeding six-year period, however, from 1929 to 1934, the average yield of wheat was only 5·4 bushels per acre with an average return value of $2.98 per acre.

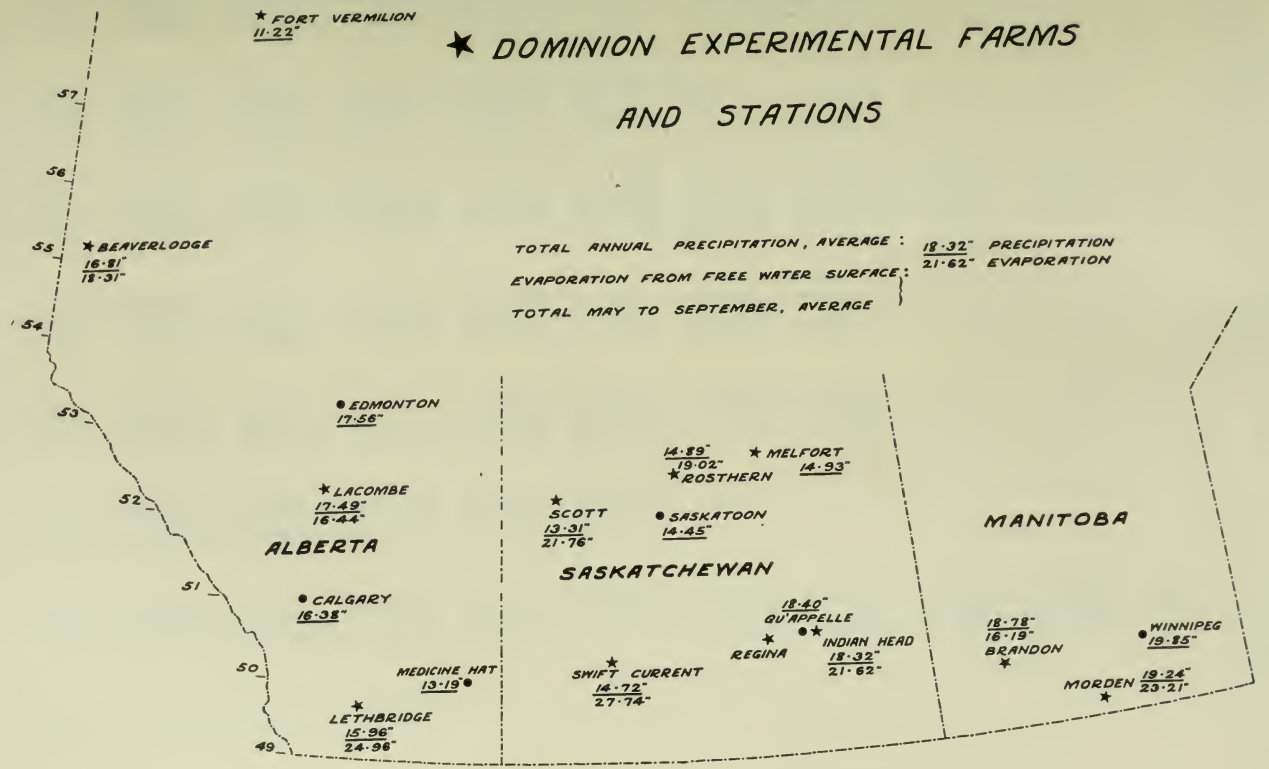
For the four-year period, from 1931 to 1934, the average return value of the wheat crop was only $1.73 per acre.

WHEAT YIELDS IN ALBERTA BY CROP DISTRICTS

TABLE 12.—YIELD PER ACRE

Crop District	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	Average yield 14 years
	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.	bush.
1	9·0	8·0	18·0	4·0	10·0	7·5	30·0	27·0	13·8	10·1	7·8	15·5	12·1	14·5	13·4
2	15·0	16·0	25·0	12·0	18·0	18·0	28·5	24·5	22·3	23·7	14·1	18·9	9·7	20·6	19·0
3	9·0	8·0	18·0	6·0	12·0	11·0	31·2	24·5	11·0	11·2	10·0	16·0	7·3	9·2	13·2
4	15·0	16·0	30·0	14·0	20·0	25·0	30·2	24·7	15·8	24·4	15·9	22·2	9·4	15·4	19·9
5	7·0	7·0	28·0	7·0	17·0	16·0	27·7	20·8	6·2	10·9	7·6	16·8	3·1	4·6	12·8
6	14·0	12·0	35·0	12·0	18·0	19·0	26·0	26·5	9·6	16·6	17·3	25·2	13·2	13·9	18·4
7	9·5	10·0	28·0	6·0	19·0	19·0	25·3	20·5	4·9	20·2	16·1	18·5	11·1	10·3	15·6
8	14·0	14·0	32·0	14·5	21·0	23·0	25·0	22·2	10·8	18·9	23·7	21·3	16·6	14·0	19·4
9	12·0	13·5	28·0	12·0	17·0	18·0	20·0	19·3	13·1	26·0	26·8	26·8	21·6	16·2	19·3
10	12·0	9·5	25·0	16·0	19·0	16·0	26·8	22·0	10·5	28·9	23·8	21·9	18·7	21·6	19·4
11	16·0	12·0	32·0	22·0	26·0	25·0	29·0	26·7	17·6	28·0	28·7	25·4	22·2	23·6	23·9
12	13·0	14·0	25·0	17·0	23·0	22·0	22·4	20·0	15·8	29·1	23·9	24·4	18·8	21·9	20·7
13	18·0	12·0	26·0	16·0	17·0	12·0	25·7	19·5	14·0	30·9	24·3	25·1	22·1	23·6	20·4
14	16·0	13·5	30·0	20·6	23·0	18·0	27·8	23·0	19·3	31·4	27·1	26·6	19·9	21·3	22·7
15	9·5	12·0	31·0	16·0	22·0	29·0	34·0	19·5	23·3	30·3	26·6	23·9	21·2	26·6	23·2
16	11·0	11·0	26·0	14·0	16·0	20·0	33·2	19·8	20·4	30·5	21·7	18·5	19·8	25·8	20·5
17	12·0	12·0	28·0	15·0	18·0	25·0	35·0	12·7	17·4	32·2	23·3	15·7	19·0	26·8	20·9

PRECIPITATION AND EVAPORATION ON THE ★ DOMINION EXPERIMENTAL FARMS AND STATIONS



TOTAL ANNUAL PRECIPITATION AT REPRESENTATIVE POINTS IN THE THREE PRAIRIE PROVINCES

TABLE 13

Year	Winnipeg Man.	Morden	Brandon	Indian Head, Sask.	Qu'Appelle	Saskatoon	Rosthern	Scott
	in.	in.	in.	in.	in.	in.	in.	in.
1884	.....	.....	.....	.....	13·97	.....	.....	.....
1885	.....	.....	.....	.....	11·92	.....	.....	.....
1886	14·38	.....	.....	.....	10·05	.....	.....	.....
1887	17·93	.....	.....	.....	14·48	.....	.....	.....
1888	16·94	.....	.....	.....	17·00	.....	.....	.....
1889	14·95	.....	.....	.....	10·54	.....	.....	.....
1890	24·91	.....	.....	.....	23·99	.....	.....	.....
1891	20·09	.....	.....	.....	19·02	.....	.....	.....
1892	19·89	.....	.....	.....	16·45	.....	.....	.....
1893	23·93	.....	.....	.....	16·35	.....	.....	.....
1894	18·14	.....	.....	.....	12·46	.....	.....	.....
1895	18·42	.....	.....	.....	15·29	.....	.....	.....
1896	26·29	.....	23·07	.....	21·63	.....	.....	.....
1897	17·59	.....	13·37	17·12	12·64	.....	.....	.....
1898	27·19	.....	21·27	20·33	21·65	.....	.....	.....
1899	19·82	.....	14·50	13·54	19·27	.....	.....	.....
1900	18·58	.....	20·42	14·94	16·52	.....	.....	.....
1901	23·90	.....	18·68	26·92	26·47	.....	.....	.....
1902	20·22	.....	23·62	16·03	24·37	.....	.....	.....
1903	16·92	16·46	19·53	19·00	20·09	.....	.....	.....
1904	23·00	28·01	22·68	20·09	22·22	19·50	.....	.....
1905	19·90	22·03	20·45	22·82	24·55	10·85	.....	.....
1906	22·54	25·94	18·77	17·61	20·29	12·57	.....	.....
1907	16·88	14·05	20·80	18·15	18·53	10·38	.....	.....
1908	21·44	20·33	17·49	17·49	18·67	14·15	.....	.....
1909	23·12	18·27	18·86	19·37	25·75	15·87	.....	.....
1910	18·89	15·03	13·98	18·73	19·02	11·04	.....	.....
1911	23·38	17·25	20·53	23·69	20·61	19·45	16·64	.....
1912	22·81	18·85	18·04	15·88	18·06	16·78	18·53	17·41
1913	15·78	13·38	12·89	23·98	21·18	13·45	15·22	11·25
1914	21·88	18·39	16·79	13·84	19·77	12·66	12·62	17·95
1915	16·97	15·40	16·01	17·00	18·67	10·50	10·18	10·37
1916	24·19	22·30	22·54	22·64	26·54	15·82	15·06	20·68
1917	13·76	14·99	11·21	13·84	16·69	12·74	14·47	7·37
1918	19·40	19·70	14·45	14·29	15·53	11·24	13·12	6·50
1919	25·13	21·30	17·17	17·53	17·92	11·59	11·98	11·16
1920	17·37	16·12	16·76	21·46	19·72	15·17	13·29	15·31
1921	22·03	22·37	22·55	25·01	27·19	20·82	20·47	13·48
1922	21·43	24·00	20·01	19·40	22·03	12·89	13·11	10·38
1923	15·70	14·50	17·46	25·68	27·05	18·73	14·46	15·41
1924	18·55	26·67	25·15	14·77	16·45	13·06	13·44	12·56
1925	16·09	20·63	18·86	16·80	16·70	16·41	17·85	16·75
1926	20·18	25·60	21·03	18·75	19·30	14·76	12·18	13·57
1927	21·45	21·76	24·13	22·91	25·55	21·28	22·67	14·89
1928	20·91	19·77	18·06	14·52	12·07	15·99	10·13	10·94
1929	14·32	14·42	15·08	13·46	12·05	11·99	13·55	9·97
1930	22·63	19·93	20·45	11·85	13·16	12·94	16·23	12·06
1931	16·92	16·02	14·82	9·02	10·72	13·70	14·85	12·60
1932	19·50	19·74	24·33	18·34	18·34	12·40	17·58	15·96
1933	20·31	18·81	19·55	20·60	19·25	12·88	16·90	11·38
1934	16·72	13·79	11·14	10·64	11·60	12·90	12·87	18·26
Average	49 years	32 years	39 years	38 years	51 years	31 years	24 years	23 years
	19·85	19·24	18·78	18·32	18·40	14·34	14·89	13·31

TOTAL ANNUAL PRECIPITATION AT REPRESENTATIVE POINTS IN THE THREE PRAIRIE PROVINCES

TABLE 14

Year	Swift Current, Sask.	Medicine Hat, Alta.	Leth-bridge	Calgary	Lacombe	Ed-monton	Beaver-lodge	Fort Ver-milion
	in.	in.	in.	in.	in.	in.	in.	in.
1883	.....	.....	.....	.....	.....	9·27	.....	.....
1884	.....	14·81	.....	.....	.....	15·71	.....	.....
1885	.....	8·64	.....	12·91	.....	15·36	.....	.....
1886	10·62	6·72	.....	11·32	.....	9·22	.....	.....
1887	18·00	9·89	.....	13·69	.....	12·50	.....	.....
1888	14·09	14·67	.....	17·51	.....	19·93	.....	.....
1889	10·46	7·96	.....	11·59	.....	8·16	.....	.....
1890	17·50	9·13	.....	15·47	.....	22·01	.....	.....
1891	24·55	13·15	.....	10·44	.....	17·90	.....	.....
1892	20·30	12·24	.....	7·91	.....	16·85	.....	.....
1893	14·54	14·60	.....	11·05	.....	17·87	.....	.....
1894	9·66	13·14	.....	11·70	.....	16·13	.....	.....
1895	12·33	14·23	.....	15·12	.....	14·68	.....	.....
1896	14·11	17·88	.....	16·05	.....	15·24	.....	.....
1897	16·24	17·27	.....	20·58	.....	14·59	.....	.....
1898	15·25	15·90	.....	16·21	.....	10·90	.....	.....
1899	19·38	22·28	.....	26·15	.....	20·89	.....	.....
1900	14·60	22·05	.....	17·57	.....	27·81	.....	.....
1901	18·58	20·80	.....	21·31	.....	27·53	.....	.....
1902	17·64	13·68	28·05	34·57	.....	20·57	.....	.....
1903	18·38	9·90	14·82	22·77	.....	21·06	.....	.....
1904	12·81	9·70	11·40	11·89	.....	19·87	.....	.....
1905	15·68	8·99	13·58	14·32	.....	15·56	.....	.....
1906	19·02	17·10	22·48	16·24	.....	19·30	.....	.....
1907	13·15	6·96	15·50	14·96	.....	16·62	.....	.....
1908	12·60	10·23	16·77	18·25	19·03	16·72	.....	.....
1909	19·26	9·79	11·69	13·66	14·37	12·94	.....	11·85
1910	11·16	6·39	7·95	12·03	13·30	14·93	.....	9·84
1911	14·29	15·84	21·32	19·47	21·43	20·67	.....	11·76
1912	14·62	10·34	13·21	21·32	21·84	20·18	.....	6·82
1913	12·60	13·62	14·17	17·03	13·75	19·54	.....	11·58
1914	12·48	12·17	16·52	16·70	18·30	25·29	.....	8·20
1915	14·27	16·13	17·27	18·32	17·34	18·64	.....	11·46
1916	24·08	17·90	24·57	13·91	22·91	20·95	10·33	13·92
1917	11·92	13·42	11·93	11·44	15·31	15·25	18·77	7·58
1918	12·22	10·20	7·62	9·12	21·62	17·86	15·13	10·72
1919	12·33	7·66	12·28	11·98	16·99	18·43	20·08	16·17
1920	11·56	10·74	14·05	14·42	12·43	18·16	22·12	12·07
1921	14·93	12·83	12·77	13·50	15·20	15·22	16·56	13·29
1922	14·27	11·54	12·34	10·61	12·45	13·77	11·90	16·64
1923	16·38	13·64	16·40	23·87	16·91	17·44	9·76	11·95
1924	16·73	9·86	16·00	24·29	19·54	18·77	17·17	8·95
1925	14·33	14·61	18·76	18·06	17·34	17·44	20·55	12·30
1926	13·76	11·90	16·23	24·36	23·49	30·83	15·33	11·95
1927	20·01	25·28	23·85	29·84	25·17	17·68	20·68	8·91
1928	10·10	7·64	18·08	16·64	16·15	15·15	14·81	7·27
1929	12·44	10·46	19·71	14·47	12·92	15·12	21·61	12·16
1930	11·57	12·73	12·34	14·49	14·84	12·40	15·95	10·86
1931	9·94	6·38	11·42	11·84	18·12	20·04	12·48	9·70
1932	14·31	16·58	19·24	21·03	22·25	15·48	15·37	10·24
1933	13·24	13·18	19·17	12·95	14·47	21·71	20·89	14·92
1934	9·17	14·10	15·27	14·10	14·84	19·30	19·86	12·82
Average	49 years 14·72	51 years 13·19	33 years 15·96	50 years 16·38	27 years 17·49	52 years 17·56	19 years 16·81	26 years 11·31

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